

10/564672

IAP20130111 13 JAN 2006

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## DESCRIPTION

### ULTRASONIC TRANSMITTING AND RECEIVING APPARATUS

#### Technical Field

The present invention relates to an ultrasonic transmitting and receiving apparatus used in an obstacle sensor, such as rear sonar and corner sonar in a vehicle.

#### Background Art

Ultrasonic transmitting and receiving apparatuses perform sensing by using ultrasonics. An ultrasonic transmitting and receiving apparatus intermittently transmits an ultrasonic pulse from a piezoelectric resonator and receives a wave reflected back from an object. The distance to the object is determined on the basis of the signal in wave transmission and reception. The piezoelectric resonator is secured to the inside of a bottom serving as a vibrating surface in a bottomed casing. However, unwanted external vibrations are prone to being conveyed from a side wall of the casing to the bottom and the piezoelectric resonator mounted to the inner face of the bottom. Furthermore, since vibrations occurring in the vibrating surface of the casing are also conveyed to the side wall of the casing, the vibrations can affect characteristics of the ultrasonic transmitting and receiving

apparatus, such as reverberation characteristics, depending on how the side wall of the casing is held.

In order to address such a problem, the following ultrasonic transmitting and receiving apparatus is described in Patent Document 1, which is shown below. The ultrasonic transmitting and receiving apparatus in Patent Document 1 includes a tubular casing in which an ultrasonic resonator is fixed to a bottom constituting a diaphragm. An external frame for supporting the tubular casing is disposed outside the tubular casing. An intervening member for absorbing the energy of vibrations is disposed between the external frame and the frame of the tubular casing.

Patent Document 1: Japanese Unexamined Patent Application  
Publication No. 2001-016694

#### Disclosure of Invention

However, the ultrasonic transmitting and receiving apparatus described in Patent Document 1 has the following problems.

The ultrasonic transmitting and receiving apparatus in Patent Document 1 includes the intervening member disposed outside the tubular casing provided with the ultrasonic resonator in order to absorb the energy of vibrations. In the case of the ultrasonic transmitting and receiving apparatus mounted on a vehicle or the like, the intervening

member cannot be directly attached to the vehicle or the like, and therefore, the external frame functioning as a support member is disposed outside the intervening member. As a result, since the intervening member and the external frame are necessary in addition to the tubular casing, the number of components is increased, thus resulting in an increased manufacturing cost. Moreover, when the ultrasonic transmitting and receiving apparatus is mounted on a vehicle or the like, a problem arises in which a layer structure of the tubular casing, the intervening member, and the external frame degrades the appearance of the vehicle or the like.

Furthermore, since a side of the bottom to which the ultrasonic resonator is mounted is arranged so as to be exposed to the outside in order to perform wave transmission and reception, the intervening member disposed between the tubular casing and the external frame is exposed to the outside. This results in unreliability, such as poor durability.

An object of the present invention is to provide an ultrasonic transmitting and receiving apparatus that solves the above problems in known techniques, is less prone to degraded characteristics caused by external vibrations, can have a reduced number of components and thus can be manufactured at low cost, has an enhanced appearance in vehicle use, and has an increased reliability, such as good

durability.

An ultrasonic transmitting and receiving apparatus according to the present invention has a structure in which a piezoelectric element is mounted to a bottom of a bottomed casing. The apparatus includes a casing including a bottom, an outer peripheral wall, and an inner peripheral wall. The outer peripheral wall is disposed on an inner face of the bottom and integrally extends away from the bottom. The inner peripheral wall is disposed on the inner face of the bottom, integrally extends away from the bottom, and is arranged inside the outer peripheral wall. The inner peripheral wall and the bottom define a first recess. The outer peripheral wall, the inner peripheral wall, and the bottom define a second recess. The apparatus further includes a piezoelectric element mounted to a portion of the bottom, the portion being exposed to the first recess, and a vibration isolating member with which the second recess is filled.

In the ultrasonic transmitting and receiving apparatus according to an aspect of the present invention, a cross section of the first recess, the cross section being surrounded by the inner peripheral wall and defined along a direction parallel to the bottom, has an anisotropic shape. Preferably, the anisotropic shape may be substantially elliptical.

In the ultrasonic transmitting and receiving apparatus according to another aspect of the present invention, the bottom includes a thick part and a thin part in the portion exposed to the first recess, the thick part being thicker than the thin part and the thin part being thinner than the thick part, and the piezoelectric element is mounted to the thick part.

In the ultrasonic transmitting and receiving apparatus according to still another aspect of the present invention, a cross section of a portion surrounded by an inside face of the outer peripheral wall, the cross section being defined along a direction parallel to the bottom, is circular.

In the ultrasonic transmitting and receiving apparatus according to a further aspect of the present invention, the thickness of the inner peripheral wall is equal to or smaller than the thickness of the outer peripheral wall.

In the ultrasonic transmitting and receiving apparatus according to the present invention described above, the casing is formed as one piece such that the bottom is integral with the inner peripheral wall and the outer peripheral wall. Therefore, a reduced number of components can suppress an increase in a manufacturing cost. Since the outermost portion of the ultrasonic transmitting and receiving apparatus is composed of the casing, the ultrasonic transmitting and receiving apparatus can be

directly mounted on a vehicle. Additionally, since the vibration isolating member is not exposed to a side adjacent to a vibrating surface, that is, the outside, an ultrasonic transmitting and receiving apparatus that has increased reliability and enhanced appearance can be provided.

#### Brief Description of the Drawings

Fig. 1 is a schematic plan view of an ultrasonic transmitting and receiving apparatus according to a first embodiment of the present invention.

Fig. 2 is a schematic cross-sectional view of the ultrasonic transmitting and receiving apparatus according to the first embodiment of the present invention.

Fig. 3 is a schematic plan view of an ultrasonic transmitting and receiving apparatus according to a second embodiment of the present invention.

Fig. 4 is a schematic cross-sectional view of the ultrasonic transmitting and receiving apparatus according to the second embodiment of the present invention.

Fig. 5 is a schematic cross-sectional view of an ultrasonic transmitting and receiving apparatus according to a third embodiment of the present invention.

Fig. 6 is a schematic plan view of an ultrasonic transmitting and receiving apparatus according to a fourth embodiment of the present invention.

Reference Numerals

- 1 casing
- 2 vibration isolating member
- 3 piezoelectric element
- 4 bottom
- 5 inner peripheral wall
- 6 outer peripheral wall
- 7 first recess
- 8 second recess
- 9a, 9b element electrodes
- 10 internal portion of the inner peripheral wall
- 11 external portion of the inner peripheral wall
- 12 thin part
- 13 thick part
- 14 vibrating surface
- d thickness of the thick part
- e thickness of the second recess
- f thickness of the inner peripheral wall
- g thickness of the outer peripheral wall
- 50, 60 ultrasonic transmitting and receiving apparatuses

Best Mode for Carrying Out the Invention

Embodiments of the present invention are described

below with reference to the accompanying drawings.

Fig. 1 is a schematic plan view of an ultrasonic transmitting and receiving apparatus according to a first embodiment of the present invention. Fig. 2 is a sectional view taken along the line A-A of Fig. 1.

In Figs. 1 and 2, an ultrasonic transmitting and receiving apparatus 50 includes a casing 1, a vibration isolating member 2, and a piezoelectric element 3.

The casing 1 includes a bottom 4, an inner peripheral wall 5, and an outer peripheral wall 6. The bottom 4 is integrally formed with the inner peripheral wall 5 and the outer peripheral wall 6. In other words, the casing 1 is formed as one piece. The inner peripheral wall 5 is disposed on an inner face of the bottom 4 and integrally extends away from the bottom 4. The outer peripheral wall 6 is also disposed on the inner face of the bottom 4 and integrally extends away from the bottom 4. The inner peripheral wall 5 is arranged inside the outer peripheral wall 6.

The casing 1 is made of, though not limited to, a metallic material. Preferable examples of the metallic material include aluminum, which is light in weight, easy to machine, and is corrosion-resistant, an aluminum alloy, and the like. In the casing 1, the bottom 4 and the inner peripheral wall 5 define a first recess 7. Inside the first

recess 7, the piezoelectric element 3 is fixed on a top surface of the bottom 4. A portion of the bottom 4 that faces the first recess 7 constitutes a vibrating surface 14.

The piezoelectric element 3 has a structure in which first and second element electrodes 9a and 9b are formed on the opposite principal faces of a piezoelectric substrate. The second element electrode 9b is bonded to a central portion of the inner face of the bottom 4 facing the first recess 7 with a conductive adhesive. The first element electrode 9a of the piezoelectric element 3 accommodated in the casing 1 is attached to a lead (not illustrated) and the like for electrical connection.

In the ultrasonic transmitting and receiving apparatus 50, when an alternating voltage is applied to the piezoelectric element 3, then the vibrating surface 14 is vibrated, a sound wave is generated, and the sound wave is emitted to an exterior B which is adjacent to an outer face of the bottom 4. In contrast, when a reflected wave from an object is received, then the vibrating surface 14 is vibrated, distortion generated by this vibration is converted into an electrical signal by the piezoelectric element 3, and detection of the object is thus performed.

The bottom 4, the inner peripheral wall 5, and the outer peripheral wall 6 define a second recess 8. The second recess 8 is filled with the vibration isolating

member 2. The vibration isolating member 2 is formed of an elastic material, such as an elastic adhesive or the like made of silicon rubber, polyurethane rubber, or the like. The vibration isolating member 2 functions to reduce reverberation vibrations in the vibrating surface 14 and shorten the reverberation time in reception. As a result, satisfactory reverberation characteristics are realized. Additionally, since the vibration isolating member 2 is arranged so as not to be in contact with the piezoelectric element 3, the vibration isolating member 2 does not affect the excitation of the piezoelectric element 3. Therefore, reverberation vibrations can be reduced without having to change the resonance frequency or the sensitivity of the ultrasonic transmitting and receiving apparatus 50. Moreover, unwanted external vibrations conveyed to the vibrating surface 14 and the piezoelectric element 3 can be reduced.

Furthermore, the structure of the casing 1 described above allows the ultrasonic transmitting and receiving apparatus 50 to be directly mounted on a vehicle 15. Since the outer face of the bottom 4 serves as a portion exposed to the exterior B when the ultrasonic transmitting and receiving apparatus 50 is mounted on the vehicle 15, the vibration isolating member 2 is not exposed to the exterior B. As a result, the durability is also increased.

A cross section of an internal portion 10 of the inner peripheral wall 5, the cross section being defined along a direction parallel to the bottom 4, has a substantially elliptical shape, in which axes perpendicular to each other have different dimensions. This structure allows directional characteristics to have anisotropy. The cross section of the internal portion 10 is not limited to an elliptical shape. If the cross section, which is defined along a direction parallel to the bottom 4, of the internal portion 10 of the outer peripheral wall 5 is not circular and has an anisotropic shape, directional characteristics are allowed to have anisotropy, as in the above case. As a result, the cross section is not limited to the substantially elliptical shape shown in Fig. 1, and may have various anisotropic shapes.

Fig. 3 is a schematic plan view of an ultrasonic transmitting and receiving apparatus according to a second embodiment of the present invention. Fig. 4 is a schematic cross-sectional view taken along the line C-C of Fig. 3. In an ultrasonic transmitting and receiving apparatus 60 shown in Figs. 3 and 4, the same reference numerals are used as in Figs. 1 and 2 for similar components. The explanation of the similar components to those in Figs. 1 and 2 is omitted.

In the ultrasonic transmitting and receiving apparatus 60 in Figs. 3 and 4, the bottom 4 includes a thin part 12

and a thick part 13 in a portion exposed to the first recess 7. The piezoelectric element 3 is fixed on the thick part 13.

In the first recess 7, the thin part 12 is formed such that the bottom 4 has a larger area in a direction of a longer axis of a substantially elliptical shape which is similar to the shape described above of the first recess 7. Therefore, the ultrasonic transmitting and receiving apparatus 60 can have a narrow directivity in the direction of the longer axis, and the ultrasonic transmitting and receiving apparatus 60 with a directivity having high anisotropy can be realized. Since the piezoelectric element 3 is mounted to the thick part 13, the impact resistance is also increased.

Fig. 5 is a schematic cross-sectional view of an ultrasonic transmitting and receiving apparatus according to a third embodiment of the present invention.

As shown in Fig. 5, the thickness  $d$  of the thick part 13 of the bottom 4 facing the first recess 7 is equal to or larger than the thickness  $e$  of the bottom 4 facing the second recess 8. This structure can further reduce conveyance of vibrations of the vibrating surface 14 to the outer peripheral wall 6 of the casing 1. In Fig. 5, the same reference numerals are used as in Fig. 4 for similar components. The explanation of the similar components is

omitted.

Fig. 6 is a schematic plan view of an ultrasonic transmitting and receiving apparatus according to a fourth embodiment of the present invention.

As shown in Fig. 6, a cross section of the internal portion 10 of the inner peripheral wall 5 and that of an external portion 11, the cross sections being parallel to the bottom 4, are elliptically shaped, and both the elliptical shapes have the same center. The thickness  $f$  of the inner peripheral wall 5 of the casing 1 is equal to or smaller than the thickness  $g$  of the outer peripheral wall 6. This structure can further reduce conveyance of vibrations of the vibrating surface 14 included in the bottom 4 to the outer peripheral wall 6 of the casing 1. In Fig. 6, the same reference numerals are used as in Fig. 3 for similar components. The explanation of the similar components is omitted.